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Maximum Allowable Pressure, PS

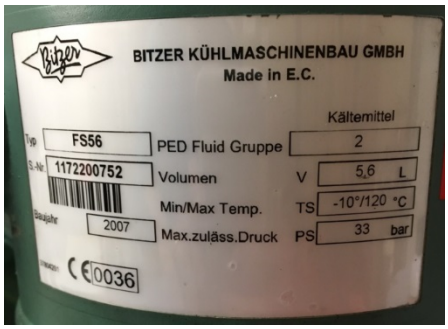
This guide explains how to calculate the maximum allowable pressure for a refrigeration, air conditioning or heat pump system and what impact it has on pressure testing and over pressure protection.

What is maximum allowable pressure

The maximum allowable pressure is the maximum pressure for which a system or component is designed [1]. It must never be exceeded, whether the system is working or not. So over pressure protection should be selected to prevent this.

Maximum allowable pressure is denoted by the symbol PS (the concept of PS and the symbol is widely used in many industries).

Individual components and assemblies such as driers and condensing units, will include the PS value(s) on the nameplate – see the example liquid receiver label. On older components it might be marked as MWP instead of PS.



How to calculate PS for systems

For most systems PS will be different for the high and low sides of the system:

- High side PS is dependent on the maximum condensing temperature because the maximum high side pressure will occur when the system is running;
- Low side PS is dependent on the maximum ambient temperature because the highest low side pressure will occur when the system is off.

For some systems the high side PS will also apply to the low side, e.g. where saturated gas defrost is used or in reverse cycle heat pumps.

EN 378 [2] provides guidance on how to calculate PS.

- Method 1 – calculate the values (e.g. from condenser TD plus allowances for fouling) or use values from test work;

[1] Definition from EN 378-1:2016 Refrigerating systems and heat pumps – Safety and environmental requirements, Part 1 Basic requirements, definitions, classification an selection criteria

[2] EN 378-2:2016 Refrigerating systems and heat pumps – Safety and environmental requirements, Part 2 Design, construction, testing, marking and documentation

- Method 2 – use specified condensing and ambient temperatures. EN 378 provides values for a range of ambient temperatures and systems as shown in the following table. This is the method usually used, although it can result in PS values that are higher than necessary.

Ambient Conditions	**≤32°C**	**≤38°C**	**≤43°C**	**≤55°C**
High pressure side with air cooled condenser	55°C	59°C	63°C	67°C
High pressure side with water cooled condenser or water heat pump	Maximum leaving water temperature +8 K but not less than the design temperature at low pressure side			
High pressure side with evaporative condenser	43°C	43°C	43°C	55°C
Low pressure side with heat exchanger exposed to the outdoor ambient temperature	32°C	38°C	43°C	55°C
Low pressure side with heat exchanger exposed to the indoor ambient temperature	27°C	33°C	38°C	38°C

We usually use 32°C maximum ambient temperature in the UK. In warmer climates higher maximum ambient temperatures are used, so the PS values are higher.

The pressure is determined from the temperature specified using the pressure / temperature relationship for the refrigerant. For zeotropic blends (R400 series refrigerants) PS is the pressure at the bubble point. Some examples are given below for air cooled condensing unit systems where the low side is exposed to outdoor ambient (ambient 32°C).

	R404A	R407A	R407F	R448A	R449A	R452A
PS, high side [3], bar g	24.8	24.9	26.1	25.3	25.3	25.9
PS, low side [4], bar g	14.1	14.0	14.7	14.3	14.3	14.7

The system PS should not be higher than the PS of individual components, assemblies and pipe work.

The PS values for R744 (carbon dioxide) systems depend on the system type. There are various criteria that should be considered when determining PS:

- The low and intermediate PS values are sufficient to reduce pressure relief valve venting in the event of a system or power failure. This does of course increase the required component and pipe work pressure rating;

[3] At 55°C condensing temp (at the bubble point for blends)
[4] At 32°C maximum ambient (at the bubble point for blends)

- There is sufficient difference between typical maximum operating pressure and PS to reduce pressure relief valve venting in the event of a small increase in pressure, especially if the PRV vent pressure has reduced due to previous relief events.

For trans-critical booster systems typical PS values are shown below:

PS, high side	120 bar g
PS, intermediate	60 bar g
PS, HT suction	52 bar g
PS, LT suction	30 bar g

Over pressure protection

EN 378 part 2 specifies the type of over pressure protection which should be fitted to systems. The requirements for high pressure switches and pressure relief valves depends on various aspects of the systems, including the system size and PS.

The table below shows the pressure at which over pressure protection should activate.

Relief pressure of pressure relief valve (where fitted)	PS
Pressure at which relief valve must have achieved full flow	≤ 1.1 PS
High pressure switch cut out pressure on systems where a pressure relief valve is fitted	≤ 0.9 PS
High pressure switch cut out pressure on systems where no pressure relief valve is fitted	≤ PS

As an example, an R407F system fitted with a high side pressure relief valve (PS is 26.1 bar g and has been determined using method 2 above):

- The PRV should vent at 26.1 bar g
- The PRV should have achieved full flow at or below 28.7 bar g
- The high pressure switch should cut out at or below 23.5 bar g.

PS and test pressures

The pressure test pressures for strength and leak tightness for systems are typically as follows [5]:

- Minimum pressure strength test pressure = 1.1 x PS
- Maximum pressure strength test pressure = 1.43 x PS
- Tightness test pressure = 1.0 x PS.

[5] As specified in EN 378-2:2016

The maximum pressure strength test is only used for joints which fall into higher hazard category [6]. These are usually joints directly onto large vessels (i.e. not onto valves or stubs on those vessels), and joints in vessels such as welds on a liquid receiver. So the maximum pressure strength test would usually be used by a manufacturer, whereas on site the joints subject to pressure testing are pipe to pipe joints or pipe to valve joints and therefore the minimum test pressure is used.

Pressure testing at lower pressures is acceptable under certain circumstances, for example if type testing has been carried out. Refer to EN 378 or the relevant product standard for further information.

PS and the Pressure Equipment Directive (PED)

PS is one of the factors which determines the hazard category of components and systems and hence the route to compliance with the PED. See Annex B of EN 378 part 2 for further information. Cool Concerns provides information and template documents to manufacturers and installers so they can demonstrate compliance with PED.

Useful conversions

For pressures in …	Multiply by …	To get pressure in …
psig	0.0689	bar g
bar g	14.5	psig
kPa	0.01	bar g
bar g	100	kPa
MPa	10	bar g
bar g	0.1	MPa

Disclaimer

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[6] Hazard categories are defined in EN378-2:2016 Annex B.